a breach of the laws of evolution, pays one of Nature's heaviest fines—loses the organs it once had.

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EXPLANATION OF PLATE VIII.—Fig. 1, mature embryo, dissected from seed. Fig. 2, tip of root of *a*, fig. 5. Fig. 3, enlarged view of 4, an embryo one-half nat. size, just escaped from seed coats. Fig. 5, seedlings, one-half nat. size. Figs. 6 and 7, accessory branching. Figs. 8 and 9, tips of embryos, enlarged; *a*, inner, lower scale; *b*, outer scale.

Development of cork-wings on certain trees. V.

EMILY L. GREGORY.

Passing now from stems of this type to those of Liquidambar, it is readily seen that whatever may be the end results, the immediate causes producing the wing are not the same as in the former type. Its eccentric development is a marked peculiarity, which, so far as I have been able to discover, occurs in no other instance. The question at once arises, whether the causes which produce eccentricity of growth in the annual rings of wood are likely to extend to the tissues arising from the cork cambium. If this were proven to be the case it might help but little in solving the problem before us, as it is a well known fact that the best authorities do not agree as to the causes of eccentric growth in woody tissues.

The function of protection which is universally assigned to the periderm naturally requires greater flexibility of structure, varying degrees of thickness, greater or less permeability for water and gases according to varying outward conditions, and, finally, greater or less outlay of material, which, in some cases, is retained, in others, discarded by the plant after it has performed its function. In this way it is easy to account for the variableness in periderm formation as illustrated in the genus Euonymus. This is more striking when contrasted with the uniformity prevailing in the structure of woody tissue. For example, when examining a large number of woods in regard to the presence or absence of bordered pores in the libriform, it was found quite unnecessary to carry the study farther than the genus. If a single species contained libriform with bordered pores, this was sufficient for the genus.

Several theories respecting eccentric growth fail at once when applied as a reason for the one-sided development of the Liquidambar wing. For example, that of gravity, which tends to produce a greater deposition of food material on the under side of horizontal branches. The wings never start from the under, but always from the upper, side of such branches. Another theory is that unequal pressure of the rind causes the inequality of growth of the ring, which is equally inapplicable in the present case. The agency of light seems a plausible theory in respect to the wings on the horizontal branches, but fails to explain their appearing first on one side of the young main axis.

On the other hand, if it be regarded from the standpoint of utility, as a contrivance to further the welfare of the plant, the question is again extremely puzzling. The probability of its serving to facilitate the interchange of gases, or affect transpiration in any way, seems much less likely than in the preceding instances. To those advocating the theory of water absorption, by various contrivances on leaves and stem, the trough-shape which the wings assume suggests the possibility of their use as water reservoirs and conductors to those parts of the stem where the water may be taken into the interior. This view is mentioned rather as a fanciful suggestion than otherwise, though both morphology and anatomy go to show the possibility of the tree making this use of the wing. It is just possible the suggestion is not more unreasonable than some similar ones made in reference to various appliances for making use of water.

There is, however, another view which suggests itself, and that is, the wing may be regarded as a contrivance for local increase of circumference without affecting the working quality of the remaining part of the periderm. By referring to fig. 18 it will be seen that on a four years' stem the circumference has been increased nearly one-half by the growth of the divided wing, the rest of the circumference remaining in the same condition as in the first season. Other branches are often nearly covered with the wing development, leaving only a narrow strip of circumference in its early condition. With increasing age comes increasing demand for protection, especially in case of the main axis. This is supplied by the corky growth extending itself to the whole circumference, while the interchange of gases is rendered possible by the breaking of tissues down to the new tender-walled cells near the phellogen layer. This tree is one of those described by

Moeller as having an internal periderm, or what is the same, producing a bark. What the connection is, or whether the knowledge of the exact structure of the internal would throw any light on the function of the superficial periderm I am not able to say.

In Euonymus alatus we have not the puzzling feature of eccentric growth, but the question of utility and the reason for such an outlay of material arises with still greater force. Here the last suggestion in reference to the wing of Liquidambar may be applied. In all the species of this genus it is an evident fact that the stem performs, in part, the office of assimilation. This is especially marked in the case of E. alatus, the chlorophyll-holding cells even having the form and arrangement of the regular palisade cells of leaves, while the number and size of leaves indicate the need of the aid of the stem in performing this labor. Now in stems even with the most exaggerated wings, both as to width and depth, it is still very evident that the entire surface, which acted as assimilating tissue before the beginning of the wings, still retains its original character and sustains the same relation to the outside air as before, during at least the first two years' growth of stem. By referring to the figures the comparatively immense gain in surface by the wing development is seen, while the surface, with the original palisade cells, remains intact and in working order. Now, were the material in these wings evenly distributed around the stem early enough to allow its growth in diameter, all assimilation of the stem would be effectually checked. By the present arrangement, the protection of a partial superficial periderm is given to the stem, assimilation is not checked, exchange or gases goes on by means of the stomata and whatever there may be taking place through the young tissue of the wing lying in lines along near the surface. It will be remembered that these walls are never suberized. The anatomy of E. Europæus and its varieties indicates a similar function. Surface growth is increased here with less outlay of material than in E. alatus, the wings never acquiring such size in the direction perpendicular to the surface.

The development of cork tissue from its beginning, was studied only in the two forms given, E. alatus and E. Europæus, var. purpurea; in these the origin of the phellogen cells was not the same, those of the first occurring about the stomata, and of the second in the thick-walled collenchymatic cells of the corner. Therefore it is not safe to draw conclusions concerning the other species where corky projections occur, but which assume other forms than wings. The so-called warty excrescences on the stem of E. verrucosus, examined after they were fully developed, showed no difference between these and the ordinary cork formation, and no traces of lenticels from which they are said to arise. One species, E. Americanus, usually shows very few traces of corky growth on its young twigs, and never, so far as I can learn, produces the wing form. Some young stems were found, however, with a distinct line of corky growth so small as almost to require the lens to render it visible. This line was neither along the corners, as in Europæus, nor exactly between them, as in alatus, but ran close along the side of each corner. This suggests very strongly the idea of transition stages. The great variety in the matter of periderm formation within this genus suggests a fertile field for farther examination.

It is quite possible that undue importance has been attached to the fact of the difference between the fall and summer growth of cells, and that the walls of the few layers of plate cells are always suberized, while those of the summer's growth for the most part show little traces of suberin. The regularity with which this occurs, and the complete encircling of the stem by one or more layers of suberized cells during the winter, seem almost conclusive evidence that this is to protect the stem during its period of winter rest, and indicates also the demand for a greater supply of air in summer than in winter. This regularity, together with the fact that in all cases studied, except the one previously mentioned, the number of the year's rings of cork agreed with that of the woody tissues suggested that the immediate cause producing these results might be the same. That is, the immediate cause producing the shortened radial diameter and usually thickened wall of the libriform cells, and the absence of tracheæ in the fall growth of woody tissue, might also be the cause of the shortened radial diameter and usually thickened wall of the fall growth of cork. Up to this time we have used the terms fall and summer growths loosely, referring to the later and earlier growth of the season. Now unless it can be proven that the time of this change of growth actually corresponds in both cases, it is evident there is nothing in the above suggestion, however plausible it may appear. This was attempted only in the case of Liquidambar, as the two other types were not available for constant daily study.

Sections cut from different Liquidambar trees, at different dates along the course of the summer's growth, and extending late into the fall, proved that the narrowing of the wood cells occurred at the same time as that of the cork cells. The work was begun too late in the season for the examination of the beginning of growth in the spring-time. Exact correspondence in time is not necessary, however, in case of the beginning of spring growth. Even were it proven that the real cambium resumed its activity a few days earlier or later than the cork cambium, this is no argument against the above hypothesis of the same cause acting on both kinds of cambium after both have been active during the summer.

Perhaps a partial apology should be made for offering the suggestion, as it seems hardly possible that this change from summer to fall growth in cork formation, which has so often been given as one of the important characteristics of cork, should not have been used in the recent investigations about the question of annual rings of wood, unless this question of correspondence in time had been thoroughly tested and found to fail. In all the recent literature to which I have had access I have found but one allusion to this, that is in the article by Gerber, before referred to. He says: "The early and late cork is like summer and fall wood, but that the time of their formation is not the same." Then he explains that the time of the beginning of the formation of the spring wood does not correspond with that of the formation of spring cork, but says nothing whatever respecting the time of beginning of fall growth.

In connection with this, a brief summary of the views about the cause of the difference between the spring and fall wood may be excused here. Sachs's theory, stated in the first edition of his text-book, was that the peculiarity of the fall wood was due to the increased pressure of the rind at that time. Later experiments have failed to support this view. Among the first objections to this theory was the frequent occurrence of double year's rings. An article by Prof. Kny[7] on this subject, written in 1880, contains a statement of previous authorities, together with his own investigations, showing conclusively that double year's rings occur. Russow,[8] in an article in 1881, speaks against the theory of

[7] L. Kny Verdoppelung des Jahresring. Verhandlung d. bot. Vereins der Provinz Brandenburg, 1880. p. 1.

[8] Russow. Entwickelung des Hoftüpfels der Membran der Holzzellen und des Jahresringes bei den Abietineen. Sitzungsber. d. natur. Ges. Dorpat, 1881. Bd. 6. Heft. 1.

rind pressure in this way: First, if this be the explanation, then it must have its effect in the rind formation, that is, there would also be year's rings in the tissues growing from the opposite or phloem side of the cambium, which does not occur. Secondly, there must be a gradual going over to this shortened diameter, as the pressure increases gradually. This is not the case. Thirdly, the pressure of fissures made in the rind by the frost is supposed to account for the diminished pressure in the spring time, but this fails to account for the fact that in the hot zones year's rings have been known to form the same as in colder climates. Russow suggested that instead of pressure on the cells from without, it was caused by a diminished turgescence within the cells, that the decrease in the amount of nourishment was the cause of this lack of turgor. Krabbe[9] next proved that the rind pressure is only very little greater in the fall than in the spring, so little as to make it impossible to be the cause of the short diameter. Moreover, the rind being cut so as to lessen the pressure rather tended to favor the production of the fall wood. Next, Wieler experimentedas to the relative turgescence of cells of spring andfall, and proved this to be about the same during the entire vegetative period, therefore he claims there must be some other cause for the manner of growth of fall wood. He holds, with Russow, that the spring wood is better nourished than that of the fall.

In a review in the Bot. Centralblatt Bd. 34, no. 2, 1888, Sanio gives a brief summary of the conflicting opinions of Wieler and Krabbe. The latter states, we have now two theories as to the cause of the fall growth of wood, viz.: Wieler's and Hartig's. Both claim it to be the varying conditions of nutrition in the fall and summer; but the one, Hartig, says the tree is better nourished in the fall than in the spring; the other holds the contrary opinion. Hartig claims that the increased nourishment of the fall is used in adding to the thickness of the wall; Wieler explains the shortened radial diameter as due to the decrease in nourishment offered in the fall, and that the thickness of these walls depends on nourishment already acquired by the tree, and that their growth in thickness is quite independent of their growth in surface. He also claims that the greater or less number of ducts is a thing "per se," that it is not a constant factor in the problem, and does not attempt an explanation of this

[9] Krabbe. Ueber das Wachsthum des Verdickungesringes und der jungen Holzzellen in seiner Abhängigkeit von Druckwirkung. Abhandl. d. Akad. d. Wiss. zu Berlin, 1884.

feature. Krabbe criticises these views, and insists that an attempted explanation of the cause of fall wood should include all the characteristics. The reviewer favors the opinion of Wieler.

These few statements contain, perhaps, the principal results hitherto attained in this direction. If it could be proven that in the majority of instances the time of change from summer to fall growth of wood does not correspond exactly with that of the change in the cork tissue, the question would then arise as to the cause of the latter. It is certainly very significant that the only constant feature, viz.: shortened radial diameter of cells, is common to both, and furthermore, that the walls of the fall cork cells are often thicker than those of the summer growth, which is so frequently true of the fall cells of wood.

On the other hand, if it could be proven that the time of this change does correspond, there would be strong reason for supposing the cause to be the same. This would invalidate the theory of rind pressure, and add much in favor of the opinion that the question is solved whenever the cause of the shortening of the radial diameter is discovered.

Owing to the difficulty of access to the living specimens at proper times for experimenting but little could be done in that direction. It is, therefore, scarcely proper to speak, in conclusion, of definite results. Various facts in regard to the anatomy of these growths have suggested certain inferences, some of which are of such a nature as to be easily proven or disproven. The most important ot these are:

I. Young stems, which are entirely encircled by cork wings, were found to lack other means of communication with the outside air. The anatomy of the wing in these cases is such as to enable it to supply this deficiency and to act as lenticels.

II. The wings of the horizontal branches of Liquidambar, covering as they do only part of the circumference, pertorm in part the same function, at the same time they increase the surface sufficiently to allow the growth within, while the remaining part of the stem's surface retains the character and office of the early periderm.

III. In Euonymus, the symmetry of the stem is preserved, the surface is enlarged by the wing, while all the remaining surface of the stem plays the part of assimilation.

IV. The characteristics of fall cork are exactly those of fall wood, the tracheal element alone excepted. Could it be proven that these changes were due to the same cause, another means of deciding the question as to the cause of the fall growth of wood, or year's rings, would be obtained.

In concluding, the author begs leave to express thanks for all assistance from friends, in the way of material kindly furnished from various sources; especially to Dr. C. S. Sargent and to Mr. Meehan, of Philadelphia.

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ERRATUM.—Page 252, line 23d from top, should read, According to the *place*, etc.

Notes on North American Mosses. I.

CHARLES R. BARNES.

About a year ago, Mr. F. H. Knowlton, of the National Museum, sent me a package of mosses collected in August, 1887, by William Palmer, mostly on the Mingan Islands, which lie between Anticosti and the southern shore of Labrador. As the publication of the bulletin concerning this collection is delayed, it is thought best to publish the list in the GAZETTE. It includes one new species.

1. *Sphagnum papillosum* Lindb. In wet woods mixed with No. 8. St. Johns, Newfoundland.

2. *Gymnostomum rupestre* Schleicher (1807). On limestone cliffs, Mingan. This is one of the forms of this polymorphous species approaching G. curvirostrum closely, but it seems hardly worth while to give it a name.

3. *Dicranum undulatum* Ehrhart. Sand beaches, among trees, Mingan. This is the D. undulatum of Lesquereux and James's Manual. *D. undulatum* Turner is *D. Bonjeani* De Not.

4. *Bryum inclinatum* Br. & Sch. On limestone cliffs, Mingan.

5. BRYUM KNOWLTONI. (§ *Cladodium.*)

Plants densely cespitose; tufts 1–2 cm. deep, interwoven with red-brown rhizoids, mottled. Stems copiously branched by innovations, reddish. Leaves closely imbricate in bud-like tufts at the top of the innovations, not twisted when dry, the youngest bright green, the older dirty yellow, 1.5–2.0 mm. long, 0.60–0.75 mm. wide, carinate concave, ovate- to obovate-lanceolate, the lower shorter, the upper narrower, all